EARLY PERFORMANCE OF SOME NATIVE AND CULTIVATED GRASSES ON OIL SANDS MINE DISTURBANCE MATERIALS

by

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1982
Edmonton

Alberta Energy and
Natural Resources

ENR Technical Report Number: T/45
International Standard Book Number: 0-86499-086-3

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ABSTRACT

The adaptability of native and cultivated grasses to oil sands disturbance materials is being studied in a field trial in northeastern Alberta. The native grasses originated from the mountains and foothills of the province.

The trial was established on blended materials consisting of native sand, clayey overburden and peat. Nine native grasses and eight cultivated grass varieties were seeded in June of 1981. First-year results, describing laboratory germination tests and field emergence; and second-year results, describing the degree of plant cover produced, are presented in this report. A description of the site as well as a summary of experimental and statistical procedures are also included.

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ACKNOWLEDGEMENTS

Acknowledgements are due to S.K. Takyi, P.F. Ziemkiewicz and R.S. Sadasivaiah for assistance in designing the experiment. S. Smoliak, Agriculture Canada Research Station, Lethbridge, Alberta, provided the sample of Elbee northern wheatgrass used in this experiment. Special thanks are due to S.K. Takyi and M. Houser for their help in establishing the trial. R. Islam assisted in the assessments of the trial.

1. INTRODUCTION

Alberta Forest Service native grass field trials have in the past focused on high-elevation reclamation. A part of this research involved assessing the adaptability of grasses to drastically-disturbed coal-mined lands in alpine and subalpine environments. The native species tested in this adaptability trial originated from the Rocky Mountains and foothills of Alberta.

The existing and proposed disturbances resulting from oil sands mining in the northeastern part of the province provided the incentive and opportunity to evaluate the adaptability of the same high-elevation native grasses to a different environment. Nine native species representing five genera were selected for this study.

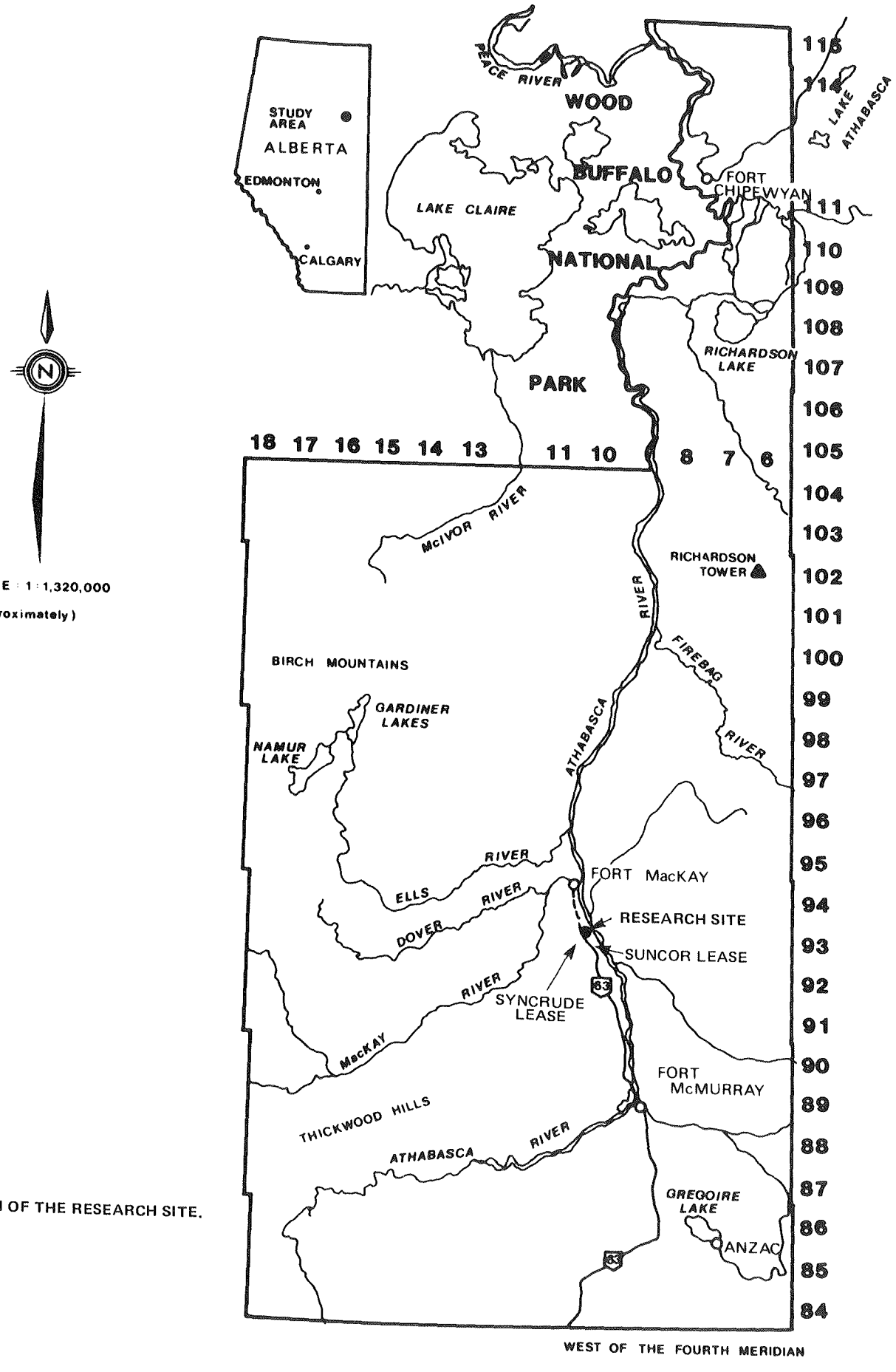
The major objective of the present trial is to evaluate and compare the performance of the nine native grasses on simulated and amended tailings sand. To increase the scope of the trial, eight cultivated grass varieties, most of which are known to be adapted to the study area, were included as treatments.

2. DESCRIPTION OF THE STUDY AREA

The study area is approximately 38 km north of Fort McMurray, Alberta, in NE 18-93-10-W4M (Figure 1). Elevation of the research site is 314 m ASL.

The general area is characterized by short cool summers and long cold winters. Total annual average precipitation is 430 mm with 280 mm occurring as rainfall (Longley and Janz 1978). The growing season is approximately 95 days from May through August (Chu and Fedkenheuer 1980).

Vegetation types in the immediate area consist of plant communities dominated by jack pine (Pinus banksiana) and to a lesser extent trembling aspen (Populus tremuloides). Common understory species include bearberry (Arctostaphylos uva-ursi), blueberry (Vaccinium myrtilloides), bog cranberry (V. vitis-idaea), rice grass (Oryzopsis pungens), Cladonia sp. and club mosses (Lycopodium sp.).



SCALE : 1 : 1,320,000
(approximately)

FIGURE 1 : LOCATION OF THE RESEARCH SITE.

3. MATERIALS AND METHODS

3.1 Site Preparation

The research site, prepared and fenced in 1979, simulates a reclamation environment of amended tailings sand for reconstruction of a soil profile. The upper soil horizons on the site were stripped to expose the sand of the C horizon. Clayey overburden and peat were then imported to the site from nearby Syncrude stockpiles and successively applied in 15 cm layers over the sand. The final steps involved tillage operations to blend these materials together with approximately 15 cm of sand.

3.2 Experimental Treatments, Design and Establishment

Nine native grass species and eight cultivated grass varieties were selected for the experiment. The native grasses were originally collected and propogated as part of a species improvement program conducted by the Department of Genetics, University of Alberta. The original seed collection sites are given in Table 1. The cultivated grass varieties are listed in Table 2.

A non-selective herbicide, Glyphosate, was applied on the site three weeks prior to trial establishment. The herbicide, in a spray formulation, was applied at a rate of 3.56 kg active ingredient per ha.

Table 1

ORIGINAL SEED COLLECTION SITES OF THE
NATIVE GRASSES USED IN THE TRIAL

Scientific Name	Common Name	University of Alberta I.D. Numbers(s)[1]	Site(s) of Original Seed Collection[2]
1. *Agropyron trachycaulum*	slender wheatgrass	Multiline: B-2-2; B-2-8; B-2-11; B-2-13; C-1-10, E-1-1; E-1-3; E-1-5; E-2-10; E-2-20; K-2-18; #108	Grassy Mountain, Mountain Park, Waterton Flats, Barnaby Ridge Smoky River
2. *Agropyron dasystachyum*	northern wheatgrass	Multiline: K-2-6; K-2-11; K-4-11; K-4-17; K-4-21; K-5-12; K-6-1	Sheep River, Ya Ha Tinda, Kootenay Plains, Mount Stearn
3. *Agropyron subsecundum*	bearded wheatgrass	Multiline: E-6-8; E-6-9; E-6-10; E-6-18; E-6-21; E-6-22; E-7-13; E-8-1; E-8-17; E-8-18	Greenock Mountain, Athabasca Ranch, Rock Lake, Smoky River
4. *Deschampsia caespitosa*	tufted hairgrass	Multiline: Beartooth Hwy. Montana; Parkers Ridge	Beartooth Hwy. Montana, Parkers Ridge
5. *Festuca saximontana*	alpine sheep fescue	Multiline: B-8-9, 10, 16, 25; C-4-23, 24, 25; J-8-6, 8, 22	Coal Valley, Mountain Park, Pyramid Lake
6. *Koeleria cristata*	June grass	Multiline: L-1-12, 18, 24, 25; L-2-1, 6, 12, 24; L-3-6, 7; L-7-11 #123; #126	Southern Alberta, Sheep River, Cat Creek Athabasca Ranch, Mount Stearn, Grotto Mountain
7. *Poa alpina*	alpine bluegrass	MUltiline: B-3-6, 15, 17, 22; C-3-10, 21, 22, 25; C-8-3, 4, 19; D-4-14; D-4-16, 17, 18, 19, 20; D-5-1, 20, 25	Grassy Mountain, Mountain Park, Coal Valley, Barnaby Ridge, Snow Creek, Sunshine
8. *Poa interior*	interior bluegrass	Whistler Mountain	Whistler Mountain
9. *Trisetum spicatum*	spike trisetum	Multiline: B-1-11, 20; C-7-18, 24, 25; L-3-18	Grassy Mountain, Coal Valley, Cat Creek

[1] 1980 harvest.

[2] Primarily from the mountains or foothills of Alberta.

Table 2

CULTIVATED GRASS VARIETIES USED IN THE TRIAL

Scientific Name	Common Name	Variety
1. *Agropyron cristatum*	crested wheatgrass	Fairway
2. *Agropyron dasystachyum*	northern wheatgrass	Elbee
3. *Agropyron riparium*	streambank wheatgrass	Sodar
4. *Agropyron trachycaulum*	slender wheatgrass	Revenue
5. *Alopecurus pratensis*	meadow foxtail	Canada No. 1
6. *Festuca rubra*	creeping red fescue	Boreal
7. *Poa compressa*	Canada bluegrass	Reubens
8. *Poa pratensis*	Kentucky bluegrass	Nugget

The trial was established June 25, 1981, on the south end of the research site (Appendix 1; Plates 1 and 2). All plots measure 2 m X 2 m with a one-metre buffer between plots and replicates. Three replicates were established, each consisting of 17 treatments arranged in a completely randomized design (Appendix 2).

The grasses were seeded by simulated drilling in rows spaced 20 cm. Ten rows were established per plot resulting in 20 m of rows in each plot. The objective was to hand seed as uniformly as possible 100 seeds per m; therefore, 2 000 seeds were required per plot. The seeding rate was not based on actual seed count, but on the 1 000-seed weight of every species (Table 3). This seeding rate did not take into account non-viable seed.

Light-weight seeds were drilled to a depth of .5 cm while heavier seeds were seeded at a depth of 1 cm. Inorganic fertilizer (10-30-10) was broadcast at a rate of 600 kg per ha following seeding.

No other site maintenance was planned after the establishment year. However, invasion of broad-leaved annual and perennial plant species into the plots necessitated the application (May 26, 1982) of a selective residual herbicide (Picloram), sprayed at a rate of 1.12 kg active ingredient per ha.

Plate 1: View of the research site immediately after trial establishment (June 25, 1981).

Plate 2: View of the research site in the second growing season (August 6, 1982).

Table 3

SEED WEIGHTS OF THE EXPERIMENTAL GRASS TREATMENTS

Species	1 000 Seed Wt. (grams)	Seed Wt. (grams)[1] per plot
Native Species		
1. *Agropyron trachycaulum*	3.70	7.40
2. *Agropyron dasystachyum*	3.30	6.60
3. *Agropyron subsecundum*	3.80	7.60
4. *Deschampsia caespitosa*	0.20	0.40
5. *Festuca saximontana*	0.40	0.80
6. *Koeleria cristata*	0.28	0.56
7. *Poa alpina*	0.30	0.60
8. *Poa interior*	0.18	0.36
9. *Trisetum spicatum*	0.22	0.44
Cultivated Species		
10. *Agropyron cristatum*	1.50	3.00
11. *Agropyron dasystachyum*	3.20	6.40
12. *Agropyron riparium*	2.70	5.40
13. *Agropyron trachycaulum*	3.00	6.00
14. *Alopecurus pratensis*[2]	2.40	4.80
15. *Festuca rubra*	1.20	2.40
16. *Poa compressa*	0.24	0.48
17. *Poa pratensis*	0.31	0.62

[1]Weight of seed required to achieve a seeding rate of 100 seeds per m.
[2]Prill-on coated.

3.3 Assessment and Analysis of 1981 Data

Germination tests were conducted on all species to determine the quality of the reclamation material. These tests were conducted by the Alberta Regional Seed Laboratory, Agriculture Canada, Edmonton, using the top-of-blotter technique under a temperature range of 15 to 25 degrees Celsius. Incubation periods ranged from 14 to 28 days, depending on species.

Seedling emergence was assessed September 23, 1981. In each plot, three one-metre linear samples were randomly selected from the rows and the total number of seedlings counted. This procedure was repeated in each plot by a different observer. The two totals were then averaged. Since the seeding rate for all species was 100 seeds per m, the maximum theoretical count of emergent seedlings was 300, minus a downwards adjustment for non-viable seed. This adjustment was based on germination test results and is directly proportional to percent germination.

Emergence count data was expressed as a percentage of the potential (adjusted) number of seedlings for each species. Analysis of variance was conducted on percent emergence data (Appendix 3). Duncan's New Multiple Range Test was used to test for significant differences among treatment means.

3.4 Assessment and Analysis of 1982 Data

Plant cover on all treatments was assessed August 6, 1982. Cover was estimated by randomly placing a .5 m X .5 m quadrat in

two locations in each plot. Plant cover was then measured as the perpendicular projection of all living above-ground plant parts expressed as a percentage of the total quadrat area. The two plant cover estimates for each plot were then averaged.

Seedhead production was defined by the presence or absence of seedheads. When present, seedhead production was further described as sparse if seedheads for each species were not observed in all three replicates.

The mean plant cover estimates of the experimental treatments were subjected to analysis of variance to test for significant differences (Appendix 4). Duncan's New Multiple Range Test was subsequently employed to test for significant differences among treatment means.

Analyses were also conducted to determine if any correlation existed between seedling emergence in the first growing season and the plant cover that developed during the second growing season (Appendix 5). The objective of these analyses was to facilitate interpretation of plant cover results i.e. how much of the variation in plant cover among treatment means could be attributed to initial establishment success and how much of the variation in results could plausibly be attributed to the adaptive and growth characteristics of each grass species.

4. RESULTS AND DISCUSSION

4.1 Laboratory Germination (1981)

Germination among native species was relatively consistent (Table 4). All species, with the exception of Trisetum spicatum, exceeded 70 percent germination. The latter species exhibited poor germination (40 percent). Among the cultivated varieties, only Agropyron trachycaulum Revenue germinated poorly (59 percent). All other cultivated varieties exceeded 80 percent germination. With the exception of the above two species, the quality of the revegetation test material was relatively consistent and required little adjustment for non-viable seed.

4.2 Field Emergence (1981)

Analysis of variance indicated that differences among treatment means (species) was highly significant (Appendix 3). The large-seeded species, specifically the Agropyrons, exhibited superior seedling emergence (Table 4). Highest emergence was recorded for Agropyron dasystachyum Elbee at 62.3 percent. With the exception of this species, no statistically significant differences occurred among treatment means of the native Agropyron species and the cultivated Agropyron varieties.

Poorest emergence was exhibited by Festuca saximontana, a native species, and Poa pratensis Nugget. The emergence for both

Table 4

SUMMARY OF LABORATORY GERMINATION TESTS
AND FIELD EMERGENCE RESULTS

1982

Species	No. Seeds/ Sample[1]	Germination Rate %	Potential No. Seedlings[3]	Actual No. Seedlings[4]	Emergence Percentage[5]
Native Species					
1. *Agropyron trachycaulum*	300[2]	97	291	144.2	49.6ab
2. *Agropyron dasystachyum*	300	93	279	127.3	45.6bc
3. *Agropyron subsecundum*	300	87	261	111.3	42.6bc
4. *Deschampsia caespitosa*	300	78	219	43.8	20.0ef
5. *Festuca saximontana*	300	92	276	23.2	8.4f
6. *Koeleria cristata*	300	78	234	53.2	22.7def
7. *Poa alpina*	300	79	237	30.3	12.8f
8. *Poa interior*	300	74	222	22.7	10.2f
9. *Trisetum spicatum*	300	40	120	17.2	14.3f
Cultivated Species					
10. *Agropyron cristatum*	300	90	270	109.0	40.4bc
11. *Agropyron dasystachyum*	300	88	264	164.5	62.3a
12. *Agropyron riparium*	300	91	273	134.0	49.1ab
13. *Agropyron trachycaulum*	300	59	177	63.3	35.8bcd
14. *Alopecurus pratensis*	300	91	273	29.5	10.8f
15. *Festuca rubra*	300	96	288	60.3	20.9def
16. *Poa compressa*	300	87	261	85.0	32.6 cde
17. *Poa pratensis*	300	81	243	20.3	8.4f

[1]A three-metre sample strip (consisting of three separate one-metre segments) established in each plot.

[2]Based on a seeding rate of 100 seeds per metre.

[3]Number of viable seeds in a three-metre strip, based on germination rate.

[4]Mean of three replicates.

[5]Mean values (of three replicates) followed by the same letter within a column are not significantly different at the five percent level based on Duncan's New Multiple Range Test.

species was 8.4 percent. Other species with poor results (less than 15 percent) included Poa alpina, Poa interior, Trisetum spicatum and Alopecurus pratensis. More native species than cultivated species exhibited poor emergence, primarily because the native species group contain a higher proportion of grasses that are small-seeded. Differentiation in results does not appear to be related to species category (native versus cultivated).

The superior performance of the large-seeded Agropyrons is consistent with other research findings. Sadasivaiah and Weijer (1981) speculated that seed size is an important factor in the establishment of grasses at high elevations. The native Agropyrons in Sadasivaiah and Weijers' studies were superior to both small-seeded native and small-seeded cultivated grass species. Tomm and Russell (1981) also noted that Agropyrons tended to out-perform other species in terms of plant cover after the first two growing seasons in similar reclamation environments. However, 1982 plant cover assessment results in this study (Section 4.5) suggest that initial establishment success on (simulated) amended tailings sand is not as critical for subsequent ground cover development as in the above high-elevation studies, presumably because of less adverse soil and climatic growth constraints.

4.3 Plant Cover (1982)

Differences in plant cover produced by the native and cultivated grass species were highly significant (Appendix 4).

The Agropyron species, both native grasses and cultivated varieties, exhibited superior revegetation capability after the second growing season (Table 5). Highest mean cover (32.7 percent) was obtained from the native Agropyron dasystachyum (Plate 3), albeit the cultivated counterpart of this species, Agropyron dasystachyum Elbee, was the poorest performer of the Agropyron species with a mean plant cover of only 16.3 percent.

Percent plant cover of the cultivated varieties as a group was generally higher and more consistent than plant cover recorded for the native species. Only Poa pratensis Nugget failed to achieve more than 10 percent cover. Among the native species, Deschampsia caespitosa, Poa interior, Trisetum spicatum and Festuca saximontana all produced less than 10 percent cover. The latter species exhibited the poorest performance of all treatments in the experiment, with a measured plant cover of only 3.7 percent. Koeleria cristata produced only slightly more cover than the above species (10.2 percent).

In addition to the Agropyrons, species showing (good) reclamation potential include Alopecurus pratensis (Canada No. 1 seed) and Poa alpina. The latter, a native grass (Plate 4), produced more cover than any other species with the exception of the native Agropyron dasystachyum.

It is difficult to determine the effect of poor germination rates on the cover produced by Agropyron trachycaulum Revenue and Trisetum spicatum. The performance of Agropyron trachycaulum Revenue was comparable to other Agropyron species with high germination rates. Conversely, Trisetum spicatum produced sparse

Table 5

PERCENT COVER AND SEEDHEAD PRODUCTION

1982

Species	Seedhead Production	Percent Ground Cover[1]
Native Species		
1. *Agropyron trachycaulum*	yes	28.0ab
2. *Agropyron dasystachyum*	yes	32.7a
3. *Agropyron subsecundum*	yes	21.5abcde
4. *Deschampsia caespitosa*	sparse	5.3gh
5. *Festuca saximontana*	sparse	3.7h
6. *Koeleria cristata*	sparse	10.2fgh
7. *Poa alpina*	no	31.3ab
8. *Poa interior*	yes	9.0fgh
9. *Trisetum spicatum*	sparse	4.3h
Cultivated Species		
10. *Agropyron cristatum*	yes	22.7abcde
11. *Agropyron dasystachyum*	yes	16.3cdefg
12. *Agropyron riparium*	yes	27.2abc
13. *Agropyron trachycaulum*	yes	24.8abcd
14. *Alopecurus pratensis*	yes	20.2bcdef
15. *Festuca rubra*	no	13.3efgh
16. *Poa compressa*	yes	15.2defgh
17. *Poa pratensis*	sparse	6.8gh

[1]Mean values (of three replicates) followed by the same letter within a column are not significantly different at the five percent level based on Duncan's New Multiple Range Test.

Plate 3: Plant cover produced by the native Agropyron dasystachyum.

Plate 4: Plant cover produced by Poa alpina.

cover; however, it should be noted that other species with high germination rates, especially Festuca saximontana, also produced little cover.

Results to date suggest that, while cultivated grasses as a group may be superior revegetation material for amended tailings sand, several native species show promise. These are Agropyron trachycaulum, Agropyron dasystachyum, Agropyron subsecundum, and Poa alpina. With the exception of Agropyron subsecundum, the performance of these species even exceeded that of any cultivated species in terms of plant cover production.

4.4 Seedhead Production (1982)

All Agropyron species displayed seedhead production in every plot these species were seeded in (Table 5). Other species showing consistent seedhead production across the experiment included Poa interior, Alopecurus pratensis (Canada No. 1 seed), and Poa compressa. Results were poorer and more variable for Deschampsia caespitosa, Festuca saximontana, Trisetum spicatum, and Poa pratensis Nugget although all these species produced some seedheads. Only Poa alpina and Festuca rubra Boreal failed to produce seedheads in the first two growing seasons. No distinct differences were apparent between the native species and the cultivated varieties.

4.5 Correlation Analyses (1981 and 1982 Data)

Analysis of the two years of data for all species indicated that percent plant cover was positively and significantly

correlated to percent emergence of viable seed (Appendix 5). However, this correlation is not as strong as may be expected. The coefficient of determination calculated for this analysis suggests that only 33 percent of the variation in plant cover is associated with first-year emergence. It should also be noted that a positive significant correlation does not necessarily imply a cause-and-effect relationship.

Good emergence success and relatively high percent plant cover characterized the performance of the large-seeded Agropyron species, with the exception of Agropyron dasystachyum Elbee. This species exhibited the highest emergence percent of all treatments in 1981, but produced less cover than any other Agropyron species in 1982. Growth habit, not plant density, appears responsible for this discrepancy. Elbee displayed a very erect growth form with slender and ascending culms and leaves, resulting in less ground coverage than other Agropyron species of comparable density.

Poa alpina and Alopecurus pratensis are examples of small-seeded species which showed poor emergence but compared favorably to the large-seeded species in terms of plant cover in the second growing season. Poa alpina is a low-growing sod-forming grass with spreading or reflexed leaves (2-5 mm wide) emerging from a thick crown. Individual plants form a dense cover. Alopecurus pratensis is a vigorous rapidly-growing bunchgrass with wide (6 mm plus) and spreading leaves. The growth habit of both these species suggests potential for revegetation, despite poor seedling emergence. Other small-

seeded species exhibited both poor emergence and sparse/patchy plant cover (Festuca saximontana, Trisetum spicatum, and Poa pratensis Nugget). Further evaluation of these species is required.

The absence of a strong correlation between emergence and plant cover is corroborated by separate correlation analyses of the native species as a group, and the cultivated varieties as a group (Appendix 5). The correlation coefficients for both analyses were not significant, although the coefficient of determination was much lower for the cultivated species. The genetically-enhanced capacity of cultivated species to produce shoot biomass may account for this difference.

The relationship of seed size to seedling emergence and subsequently, plant cover, was not specifically addressed in this study. However, the data do suggest that, for the majority of small-seeded species, higher seeding rates are required to offset poor establishment results in the first growing season.

5. CONCLUSIONS

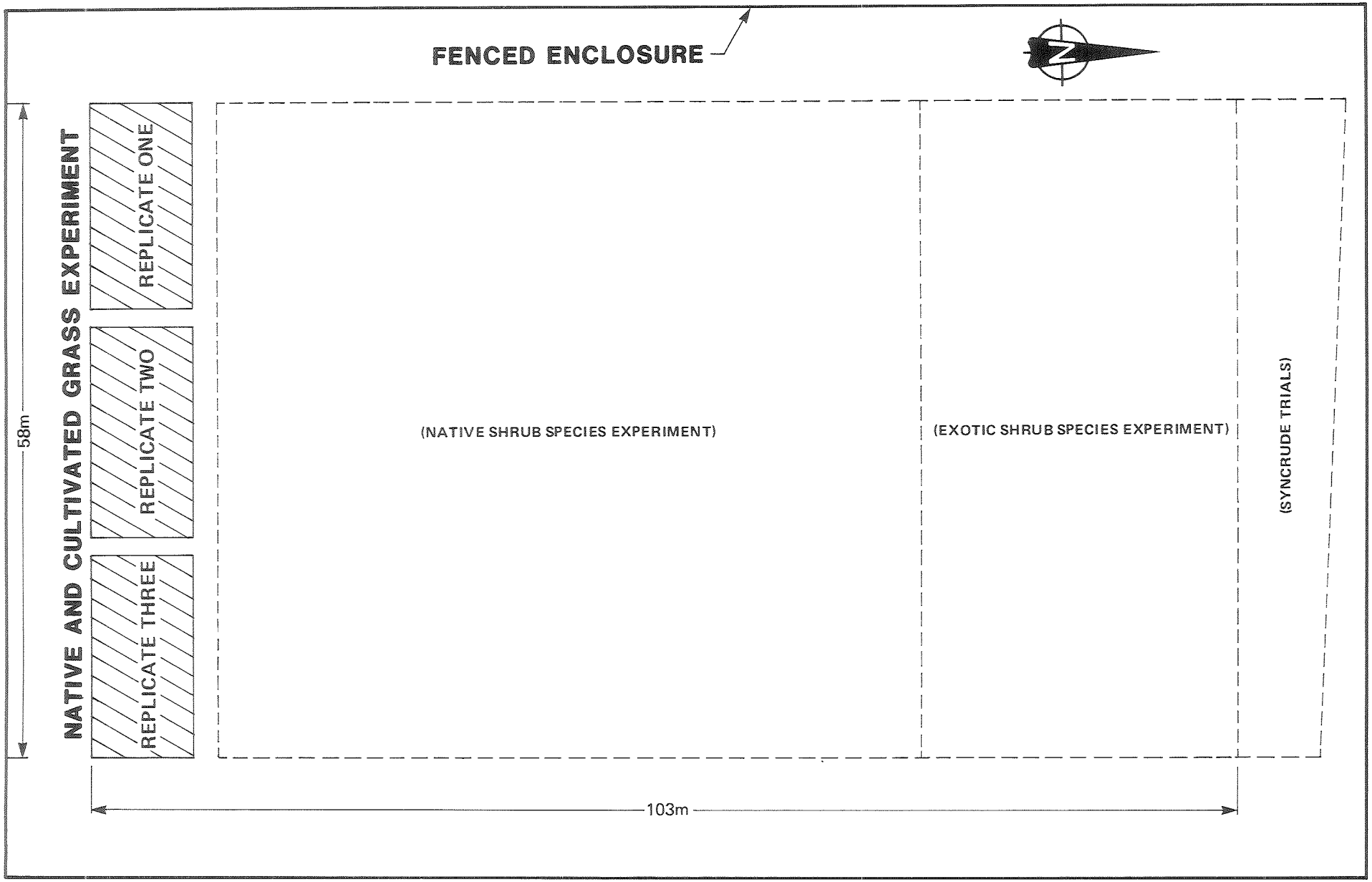
Laboratory germination test results of both the native species and the cultivated varieties tended to be uniformly good. The exceptions were Trisetum spicatum and Agropyron trachycaulum Revenue. The effect of poor germination on the production of plant cover by these species is, however, difficult to determine.

The larger-seeded Agropyron species exhibited the most successful emergence in the field. The best result was obtained from Agropyron dasystachyum Elbee. The poorest performances were obtained from Festuca saximontana and Poa pratensis Nugget. Seed size appears to be an important factor in determining emergence success on (simulated) amended tailings sand, although subsequent plant cover development is not strongly correlated to emergence.

Superior plant cover after two growing seasons was exhibited by both native and cultivated Agropyron species. Other species showing good potential for revegetation include Poa alpina (a native species) and Alopecurus pratensis. More native species than cultivated species exhibited poor plant cover.

Appendix 1

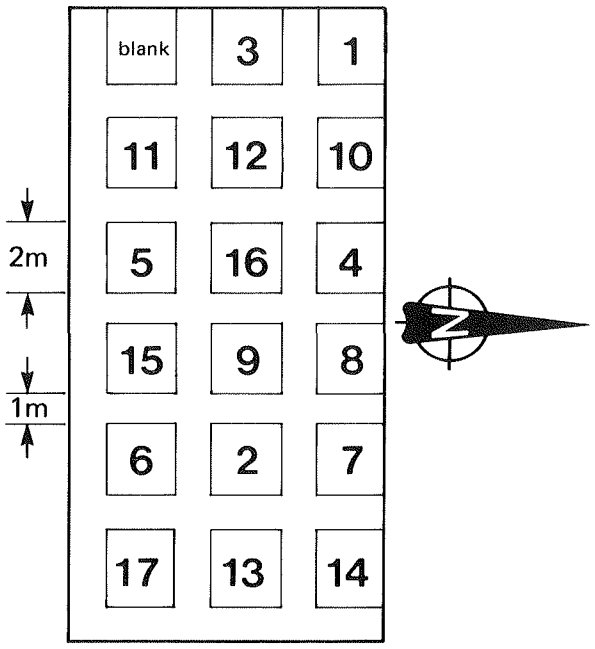
OVERVIEW OF THE RESEARCH SITE (NE 18-93-10-W4)



Appendix 2

PLOT LAYOUT OF THE NATIVE AND CULTIVATED GRASS TRIAL

Replicate One



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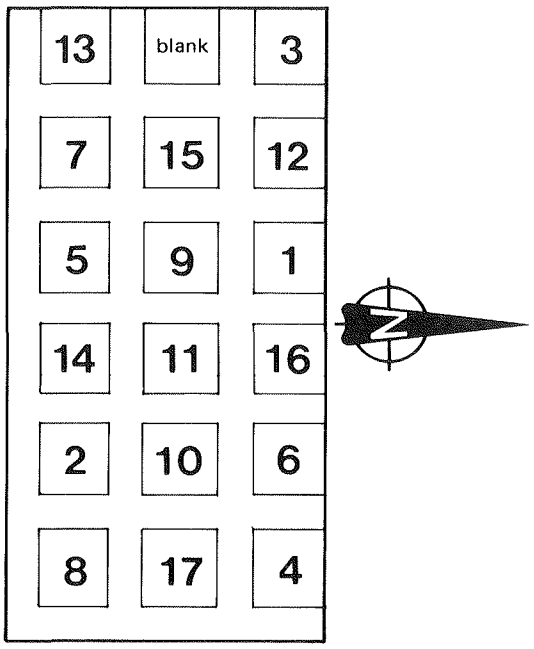

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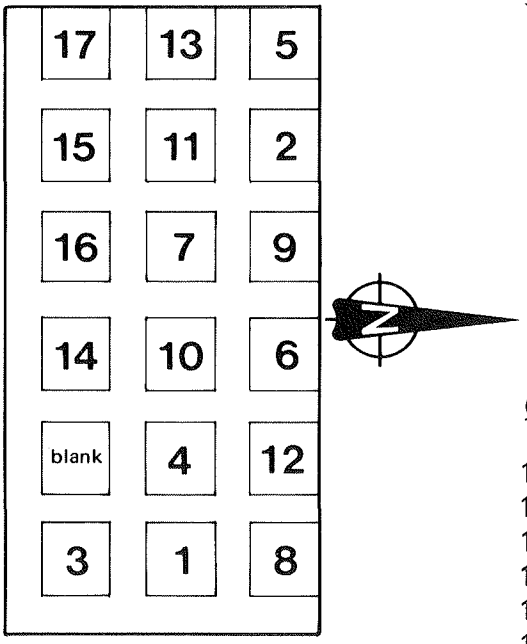

KEY TO TREATMENTS

NATIVE SPECIES

1. *Agropyron trachycaulum*
2. *Agropyron dasystachyum*
3. *Agropyron subsecundum*
4. *Deschampsia caespitosa*
5. *Festuca saximontana*
6. *Koeleria cristata*
7. *Poa alpina*
8. *Poa interior*
9. *Trisetum spicatum*

CULTIVATED SPECIES

10. *Agropyron cristatum*	Fairway
11. *Agropyron dasystachyum*	Elbee
12. *Agropyron riparium*	Sodar
13. *Agropyron trachycaulum*	Revenue
14. *Alopecurus pratensis*	Canada No. 1
15. *Festuca rubra*	Boreal
16. *Poa compressa*	Reubens
17. *Poa pratensis*	Nugget

[1] For field layout of the replicates on the research site, see Appendix 1.

Appendix 3

ANALYSIS OF VARIANCE OF PERCENT EMERGENCE DATA

1981

Source of Variation	DF	SS	MS	F
Main Effects	18			
Replicates	2	1 450.51	725.26	10.57**
Species	16	14 352.12	897.01	13.57**
Error	32	2 196.09	68.63	
TOTAL	50	17 998.73		

**Significant at P=.01

Appendix 4

ANALYSIS OF VARIANCE OF PERCENT COVER DATA

1982

Source of Variation	DF	SS	MS	F
Main Effects	18			
Replicates	2	1 320.21	660.10	18.18**
Species	16	4 511.75	281.98	7.76**
Error	32	1 162.08		
TOTAL	50	6 994.04		

**Significant at P=.01

Appendix 5

CORRELATION ANALYSIS OF 1981 FIELD EMERGENCE DATA

AND 1982 PLANT COVER DATA

Data Compilation

Species	Emergence Percentage(X)	X^2	Percent Plant Cover(Y)	Y^2	XY
Native Species					
Agropyron trachycaulum	49.6	2 460.2	28.0	784.0	1 388.8
Agropyron dasystachyum	45.6	2 079.4	32.7	1 069.3	1 491.1
Agropyron subsecundum	42.6	1 814.8	21.5	462.2	915.9
Deschampsia caespitosa	20.0	400.0	5.3	28.1	106.0
Festuca saximontana	8.4	70.6	3.7	13.7	31.1
Koeleria cristata	22.7	515.3	10.2	104.0	231.5
Poa alpina	12.8	163.8	31.3	979.7	400.6
Poa interior	10.2	104.0	9.0	81.0	91.8
Trisetum spicatum	14.3	204.5	4.3	18.5	61.5
Cultivated Species					
Agropyron cristatum	40.0	1 632.2	22.7	515.3	917.1
Agropyron dasystachyum	62.3	3 881.3	16.3	265.7	1 015.5
Agropyron riparium	49.1	2 410.8	27.2	739.8	1 335.5
Agropyron trachycaulum	35.8	1 281.6	24.8	615.0	887.8
Alopecurus pratensis	10.8	116.6	20.2	408.0	218.2
Festuca rubra	20.9	436.8	13.3	176.9	278.0
Poa compressa	32.6	1 062.8	15.2	231.0	495.5
Poa pratensis	8.4	70.6	6.8	46.2	57.1
TOTALS	486.5	18 705.2	292.5	6 538.6	9 923.1

Correlation Analysis - All Treatments

df= 15

r_{xy}= .578*

r^2_{xy}= .33

Correlation Analysis - Native Species Only

df= 7

r_{xy}= .664

r^2_{xy}= .44

Correlation Analysis - Cultivated Species Only

df= 6

r_{xy}=.501

r^2_{xy}= .25

* Significant value at the five percent level.

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